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Abstract title: Embedding a water vapor radiometer function into a 34-meter beam waveguide radio telescope: experimental results which compare the noise temperatures from an embedded radiometer with those of an external radiometer.

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Abstract:

Brightness temperature measurements at 22.2 GHz, 23.8 GHz, and 31.4 GHz collected by a water vapor radiometer (WVR) embedded within the optics of a 34 meter beam waveguide (BWG) antenna at NASA's Deep Space Network (DSN) facility at Goldstone, California are presented and compared with simultaneous measurements from an identical reference radiometer located outside of the beam waveguide. The objective of these tests is to measure the noise temperature of the DSN antenna and to assess the feasibility and benefits of measuring tropospheric water vapor with an embedded microwave radiometer. Such a system would potentially reduce path delay estimation errors associated with the antenna offset and beam mismatch of the current stand-alone WVR.

The data show that the excess noise temperature of the BWG antenna is considerable- on the order of 6 to 12 Kelvin- and that the noise temperature varies greatly depending on azimuth and elevation positions, feedhorn gain and alignment, and ambient temperature. The data also show that the excess noise of the BWG is a very smooth function of these variables. For time scales of up to 300 seconds and spatial scales up to about 30 degrees the excess noise during individual azimuth scans of the antenna while at 20 degrees elevation angle can be fit to within 0.03K with a radiative transfer model that involves a 3-harmonic Fourier expansion versus azimuth. Above 45 degrees of elevation angle the excess noise can be fit to about 0.01K for the same spatial and temporal scales. Sidelobe contamination is believed to determine these error levels. At longer time scales (3 days at a fixed zenith position) fits versus ambient temperature and surface humidity show residual errors on the order of 0.1K. At short time scales of less than ~300 seconds the difference between the embedded and the external measurements are shown to be dominated by the atmospheric variability and sampling differences associated with antenna pattern mismatch and the spatial offset between the two systems. These results indicate that an embedded radiometer operating in conjunction with an external radiometer would offer significant advantages over the stand-alone external radiometer on short time scales. Such measurements would fill a gap in present tropospheric path delay calibration capabilities time scales of less than 300 seconds.